



Flow Summary for Gaging Stations on Selected Tributaries of the Walla Walla River

Abstract

Between May and November 2002, the Department of Ecology conducted a streamflow assessment on two tributaries to the Walla Walla River: the Touchet River and Yellowhawk Creek.

The assessment was conducted in support of a temperature Total Maximum Daily Load (TMDL) study developed by Ecology's Environmental Assessment Program. The purpose of the TMDL study was to characterize the water temperature in the basin and to establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature.

Continuous stage height recorders and staff gages or bridge reference points were installed at four sites, and at least six discharge measurements were taken at each site. Discharge rating curves were developed by relating several stage height values to corresponding discharge measurements. Applying these rating curves over the range of stage height enabled a continuous discharge record to be developed at each site.

Only one of the four sites monitored in this study produced discharge data that are accurate to within 10%. Channel aggradation, aquatic weed growth, and human interference were the primary causes of error in discharge data.

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Introduction

Between May and November 2002, the Environmental Assessment Program of the Department of Ecology (Ecology) conducted a streamflow assessment on two tributaries to the Walla Walla River: the Touchet River and Yellowhawk Creek. This monitoring was conducted in support of a temperature Total Maximum Daily Load (TMDL) study developed by the Environmental Assessment Program. The purpose of the TMDL study was to characterize the water temperature in the basin and to establish load and wasteload allocations for the heat sources to meet water quality standards for surface water temperature. The study was initiated because of the federal Clean Water Act 303(d) listings of river segments which are water quality limited for temperature (LeMoine and Stohr 2002).

Sites

The Walla Walla basin covers a 1,758 square mile area, with about 70% located in Washington State. The predominant land use in the basin is agricultural, with both irrigated and non-irrigated crops. The Touchet River, the largest tributary to the Walla Walla River, originates deep in the Blue Mountains, and flows through the cities of Dayton, Waitsburg, and Prescott to its confluence with the Walla Walla River near the town of Touchet. Yellowhawk Creek carries water diverted from Mill Creek east of the city of Walla Walla to its confluence with the Walla Walla River near the Oregon border.

For this study, Ecology established continuous stage height recorders at four locations in the basin: three on the mainstem Touchet River, and one on Yellowhawk Creek. On the Touchet River, the lowest station was located at Luckenbill Road, at river mile (RM) 17.9 (Figure 1, Site 1). The middle station was located at a historical U. S. Geological Survey gage site at the Highway 124 crossing at Bolles, between the towns of Prescott and Waitsburg, at RM 40.4 (Site 2). The uppermost station was located at Dayton City Park, at RM 53.7 (Site 3). The station on Yellowhawk Creek was located on private property about 200 feet above the confluence with the Walla Walla River (Site 4).

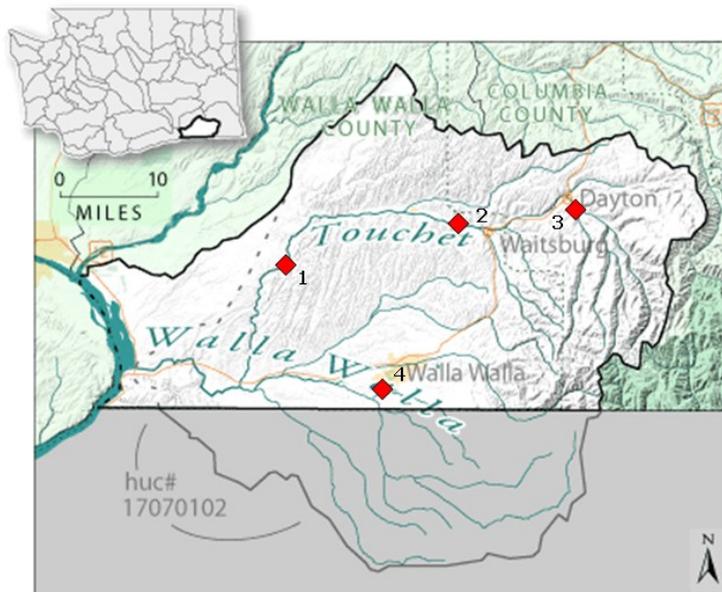


Figure 1: Map of Walla Walla TMDL study sites.

Methods

Each of the four continuous gaging stations was equipped with a pressure transducer and datalogger that recorded stage height and water temperature at 15-minute intervals from May to November 2002. Six or seven discharge measurements were taken at each station to establish discharge rating curves, which model the relationship between stage and discharge. These rating curves were then used to calculate the average daily discharges for each site.

Discharge measurements were made following the USGS mid-section method (Rantz et al, 1982). Ecology has made minor modifications to the USGS method to accommodate its measurement equipment (Hopkins, 1999). The flow measurement cross sections were established by driving re-bar into opposing banks perpendicular to the stream flow. This allowed field staff to return to the same cross-section at different stage heights and added to the reliability of the measured discharge data. In general, the cross-sections were divided into approximately 20 cells so that no more than 10% of the total discharge passed through any single cell. The width of the individual cells varied in keeping with the 10% discharge criteria. Velocity measurements were taken at 60% of the stream depth when the total stream depth was less than 1.5 ft and at 20% and 80% of the stream depth when the depth was greater than 1.5 ft (Hopkins, 1999). The instream velocity measurements were taken using a standard USGS top set wading rod fitted for Swoffer type optical sensors and propellers. Stream discharge was calculated using the USGS mid-section method in the office using a specialized discharge calculation software program developed by Ecology.

Quality Assurance

Quality assurance measures were taken during this study to address error inherent in the instream discharge measurements, and error in stage height record produced by the dataloggers, and error inherent in instream discharge measurements.

Discharge Measurements

Because the largest potential source of error involved with a discharge measurement is in the velocity measurement itself, site selection and equipment calibration are of high importance. In this study, the measured cross-sections were qualitatively rated between excellent and poor, based on physical conditions encountered at each site. An excellent cross-section, which lies in a straight channel segment with laminar flow and fairly fine-grained substrate, assumes an error of up to 2%. A poor cross-section, which lies in proximity to bends in the stream channel with turbulent flow and cobble or boulder substrate, assumes an error of over 8%. Depending on the selected cross-section, a minimum of the assigned error is assumed and carried forward to the final discharge calculation. An additional source of error in velocity measurements is the calibration of the Swoffer instruments. The ideal calibration setting of a Swoffer propeller is 186, which means that for every 186 revolutions of the propeller, 10 lineal feet of water have passed the measurement point. The calibration settings for Swoffer meters used during this project were checked before and after each discharge

measurement, with values ranging from 185 to 187. A calibration value of 185 overestimates the discharge measurement by 0.5%. Similarly, a calibration value of 187 underestimates the discharge measurement by 0.5%.

Once a discharge rating curve was established for a site, discharge measurements were tracked by comparing the measured discharge values to the discharge values predicted by the rating curve at the same stage. The combination of propeller variations, poor cross-sectional characteristics, dynamic channel geometry, aquatic weed growth, and high bottom roughness caused by low-flow conditions contributed to the measured and predicted discharge differences ranging from 0.1% to 25%. This range of differences between measured and predicted discharge demonstrates the ability of the rating curves to predict stream discharge for each site.

Pressure Transducers and Staff Gages

Based on manufacturer specifications, the theoretical precision of the pressure transducers is less than or equal to 0.02% of the full-scale output. For the transducers used by Ecology, this precision is considered linear from 0 to 15 pounds per square inch (psi), or 0 to 34.6 feet (Fletcher, 2.6). During the study period, the accuracy of each transducer was addressed by using staff gage versus transducer regressions. For two of the stations, measurements from established reference points (RPs) to water surface at bridge crossings were used in place of staff gage readings. At these sites RP readings were regressed against pressure transducer readings. The coefficient of determination (r^2) values for the regressions of raw pressure transducer readings against staff gage or RP readings ranged from 0.976 to 1.0; 1.0 being a perfect correlation. Time-weighted corrective adjustments were then made to the individual data sets to compensate for instrument “drift”. A time-weighted adjustment assumes that instrument drift occurs gradually and evenly over time, and the adjustments are applied in the same manner. After time-weighted data adjustments were applied to each data set, the r^2 values for the regressions of transducer against staff gage or RP readings were all 1.0.

Results

Site 1: Touchet River at Luckenbill Road

The average daily discharge for Site 1 ranged from 17 cubic feet per second (cfs) in mid-August to over 350 cfs during spring snowmelt in late May. Peak flow during the study was over 375 cfs on May 30 (Figure 2). Daily discharge averages are presented in Appendix A, Table 1. The discharge rating curve for this site encompassed over 85% of the range of discharge encountered, with flow measurements ranging from 25 cfs to 360 cfs (Figure 3). Discharge exceeded the rating curve approximately 15% of the time over the duration of the study (Figure 4).

Within the range of measured flows, the fit of the rating curve was very good. Five of the six discharge measurements taken at Site 1 were within 2% of the flow predicted by the rating

curve. The sixth discharge measurement, taken on October 17, was not used in the development of the rating curve because of a poor fit. Velocities for the October 17 measurement were consistent with other discharge measurements taken at the site, but the cross-sectional area was less than expected for the stage height of the river. A comparison of measurements taken at similar stage heights reveals possible gradual streambed aggradation over the course of the study, possibly facilitated by aquatic weed growth at the site (Figure 5). However, discharge did not seem to be impacted by this change at any other point in time. The measurement in question was, therefore, not used in the discharge rating curve. The linear regression of staff gage readings against pressure transducer readings showed a perfect correlation ($r^2 = 1$) (Figure 6). No corrective adjustments were necessary for data produced at this site.

Overall margin of error for discharge data for this site is estimated to be $\pm 10\%$.



Figure 2: Discharge hydrograph for Site 1.

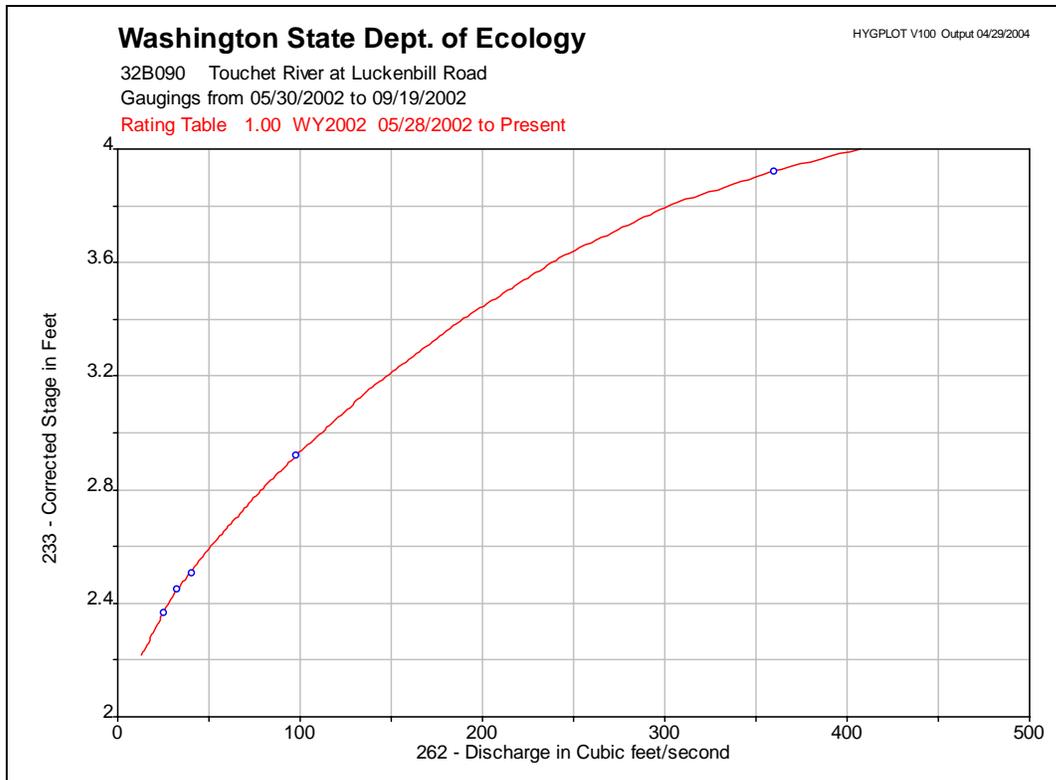


Figure 3: Discharge rating curve for Site 1.

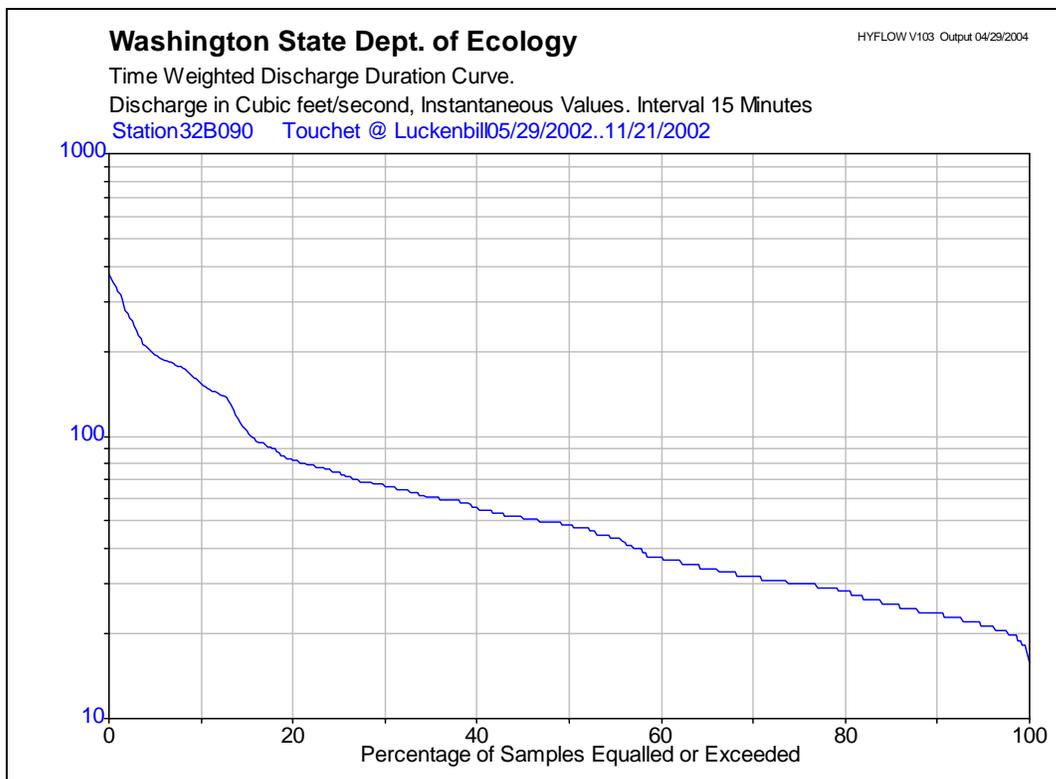


Figure 4: Flow exceedence graph for Site 1.

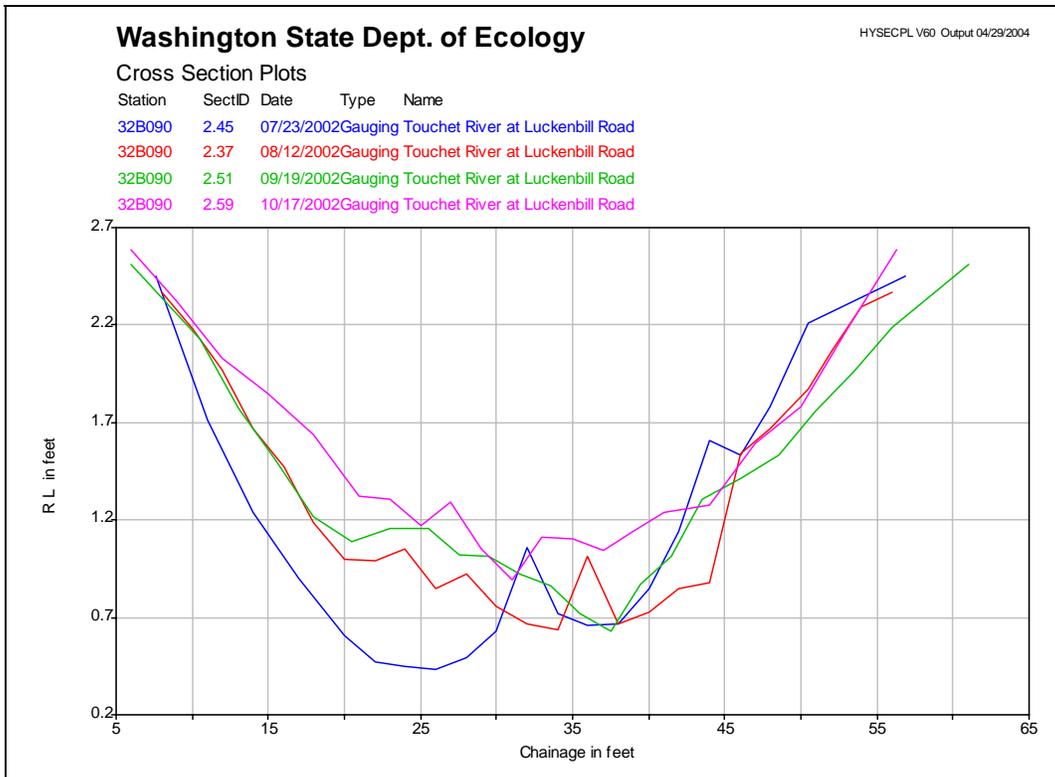


Figure 5: Comparison of cross-sectional profiles at Site 1.

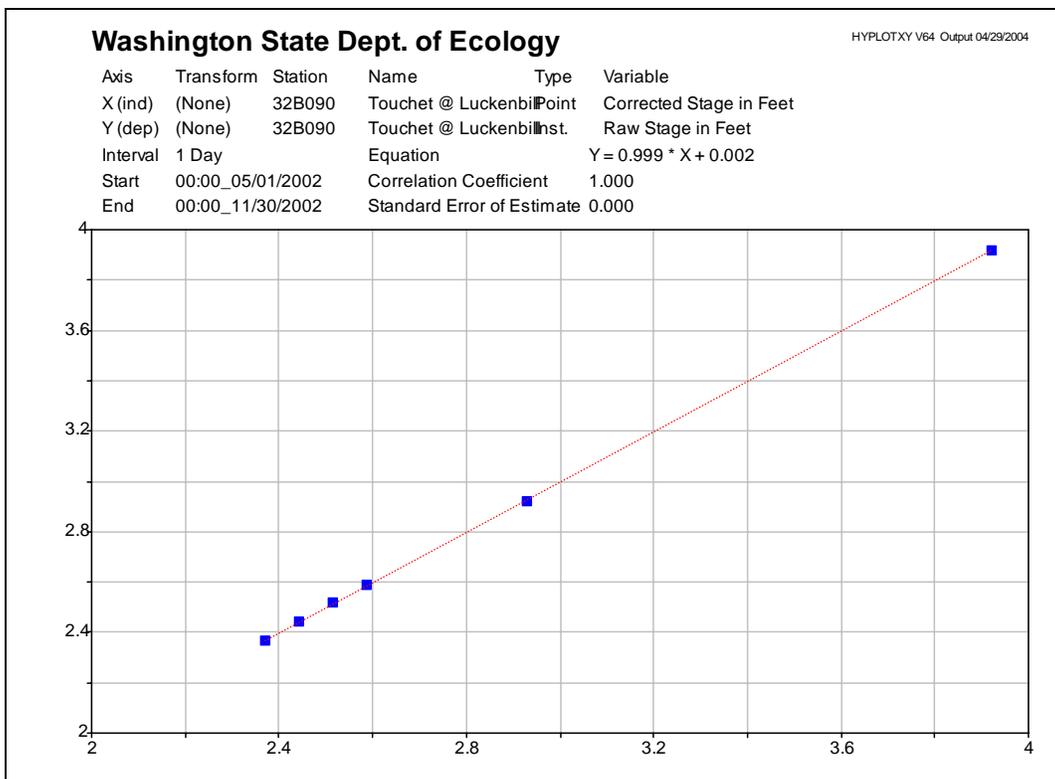


Figure 6: Linear regression of staff gage versus pressure transducer readings for Site 1.

Site 2: Touchet River at Bolles

The average daily discharge for Site 2 ranged from 26 cfs in mid-September to over 280 cfs during spring snowmelt in late-May. Peak flow during the study period was over 300 cfs on May 30 (Figure 7). Daily discharge averages are presented in Appendix A, Table 2. The discharge rating curve for Site 2 encompassed nearly 90% of the range of discharge encountered at the site, with flow measurements ranging from 34 cfs to over 330 cfs (Figure 8). However, discharge at the site was below the rated range of flows nearly 15% of the time over the duration of the study, but was above the rated range of flows less than 1% of the time (Figure 9).

Within the range of measured flows, the fit of the rating curve was very good. Six of the seven discharge measurements taken at Site 2 were within 5% of the flow predicted by the rating curve, and all seven were within 10%. Several adjustments were made to the continuous stage height data at Site 2 to compensate for drift in the pressure transducer readings. The most common causes of pressure transducer drift are sediment buildup inside the stilling pipe that protects the pressure transducer, and entombment of the pressure transducer in the substrate. Before data adjustments were made, a linear regression of RP readings, or “tape down” readings, against pressure transducer readings had an r^2 of 0.99, indicating only a nominal amount of drift (Figure 10).

Note that in the regression in Figure 10, there are only three values. The datalogger at Site 2 had an unusually high rate of battery consumption. A freshly charged 12 volt battery would typically last 15 to 40 days, with no predictable pattern. Due to the remote location of the site relative to Ecology headquarters in Olympia, more frequent visits were not feasible. As a result, there were several gaps in the data record ranging from two to fifteen days. Continuous stage height data from the Touchet River at Luckenbill Road station (Site 1) were regressed against stage height data from Site 2. Data from Site 1 were then adjusted and used to fill any gaps in the data record for site 2. These time periods are noted in Appendix A, Table 2.

Due to the gaps in the stage height record, coupled with logger drift, the total margin of error for discharge data for Site 2 is estimated at $\pm 20\%$ for periods where data from surrogate stations were used to supplement the stage record. The margin of error for discharge data outside these periods is estimated at $\pm 10\%$.

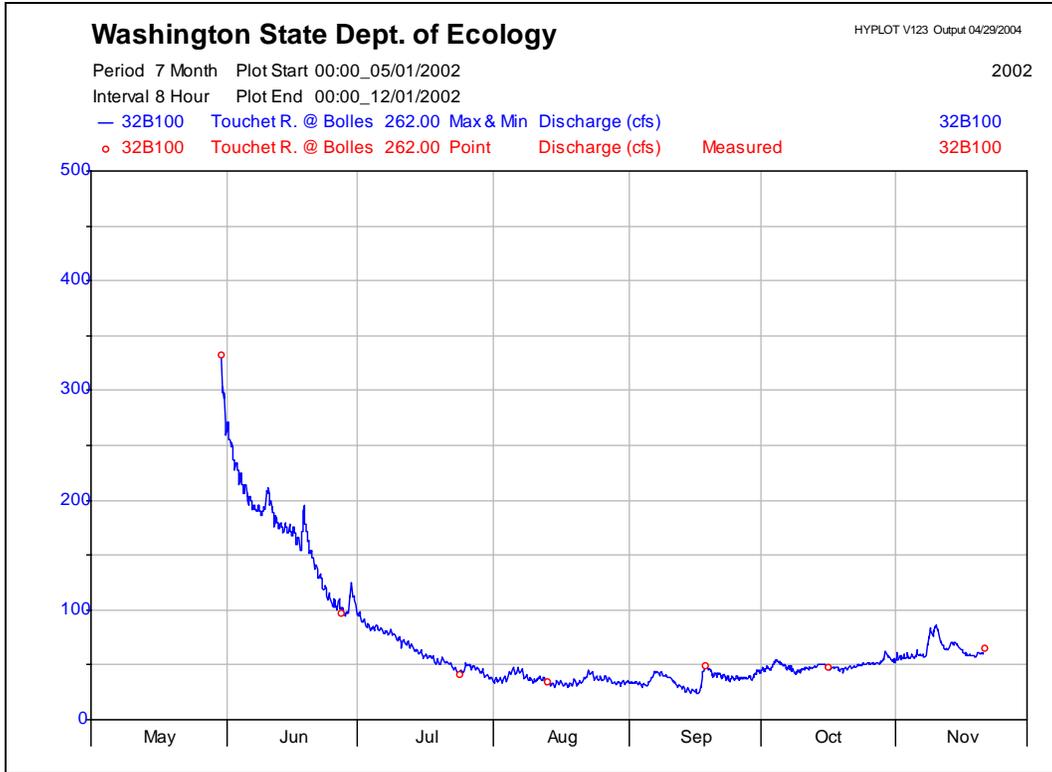


Figure 7: Discharge hydrograph for Site 2.

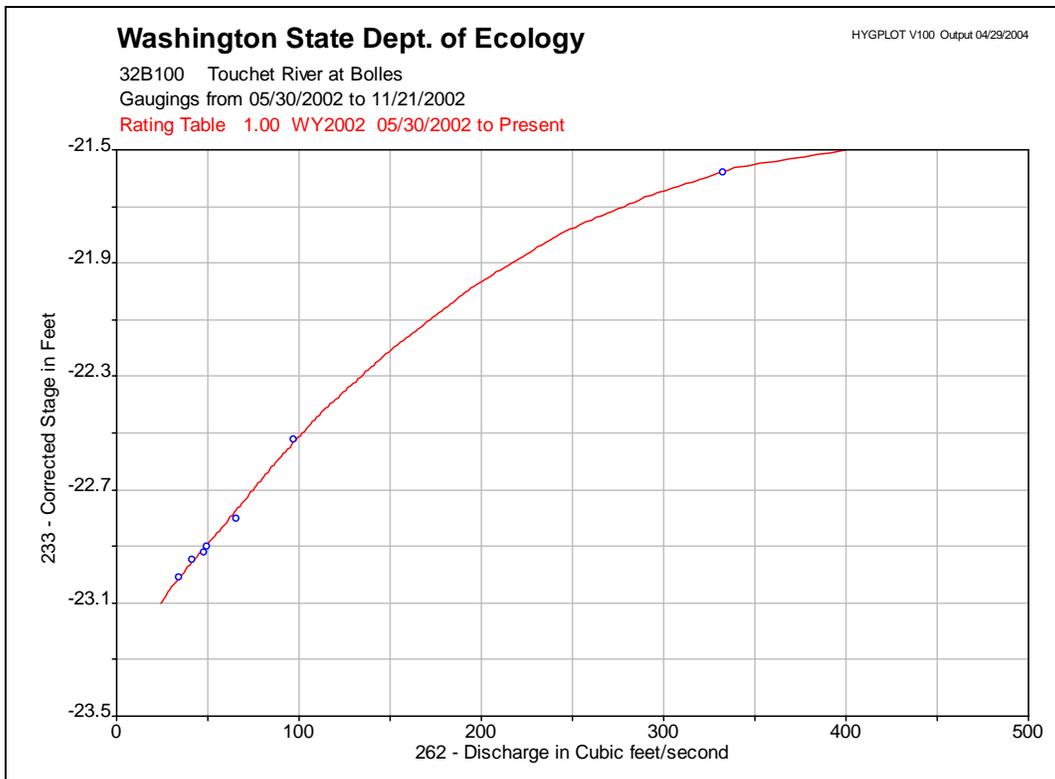


Figure 8: Discharge rating curve for Site 2.

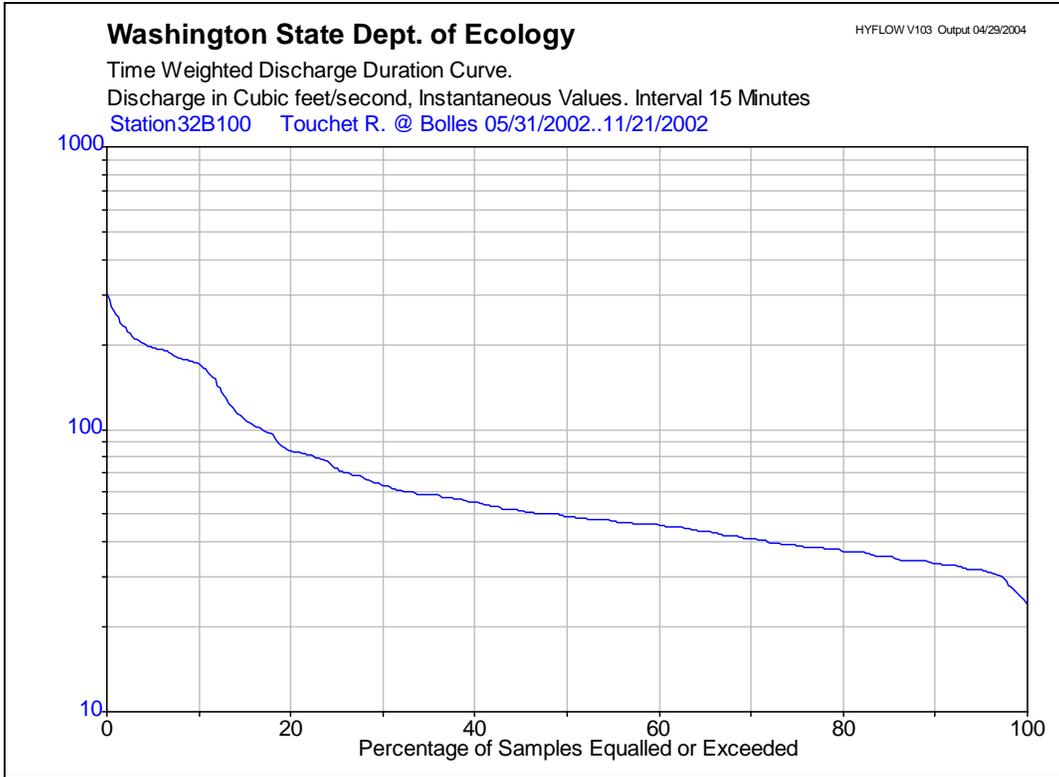


Figure 9: Flow exceedence graph for Site 2.

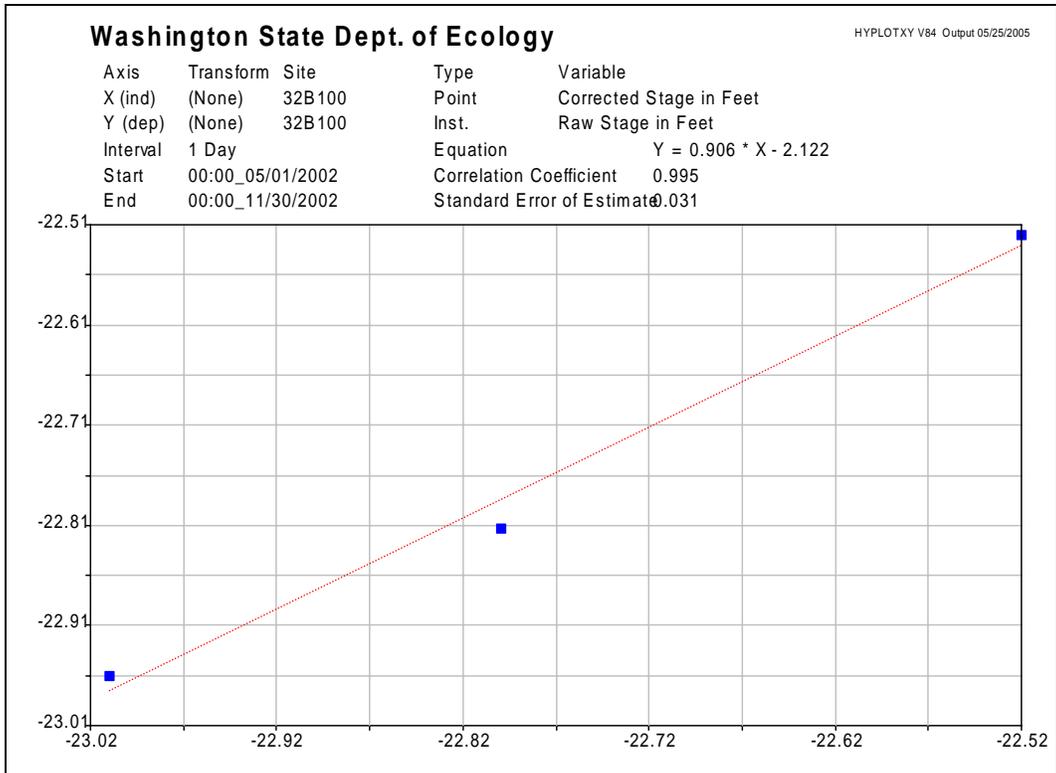


Figure 10: Linear regression of tape down versus pressure transducer readings for Site 2.

Site 3: Touchet River above Dayton

The average daily discharge for Site 3 ranged from 25 cfs in mid-September to nearly 320 cfs during spring snowmelt in May. Peak flow during the study period was 370 cfs on May 31 (Figure 11). Daily discharge averages are presented in Appendix A, Table 3. The discharge rating curve for this site encompassed nearly 75% of the range of discharge encountered, with flow measurements ranging from 29 cfs to 285 cfs (Figure 12). Discharge exceeded the rating curve approximately 15% of the time over the duration of the study (Figure 13). In mid-July during the study, an earthen dam was constructed in the river channel 50 yards downstream of the station as part of an irrigation diversion. The dam impacted the relationship between stage and discharge, elevating river stage and slowing water velocities. A new rating curve was developed for the station to account for this change (Figure 14). In early-October the dam was breached, and the relationship between stage and discharge returned to normal, as verified by subsequent discharge measurements.

Within the range of measured flows, the fit of the rating curve was very good. All seven of the discharge measurements taken at Site 3 were within 6% of the flow predicted by the rating curve. The pressure transducer at this site seemed to be highly susceptible to drift. The reason for this drift is unknown, but could have been the exertion of velocity pressure on the transducer, which can cause falsely elevated readings. However, before corrective adjustments were made to the continuous data, a linear regression of staff gage readings against pressure transducer readings had an r^2 of 0.994, indicating that instrument drift was not severe at this site (Figure 15).

Within the range of flows encountered at Site 3, the overall margin of error is estimated to be $\pm 15\%$.

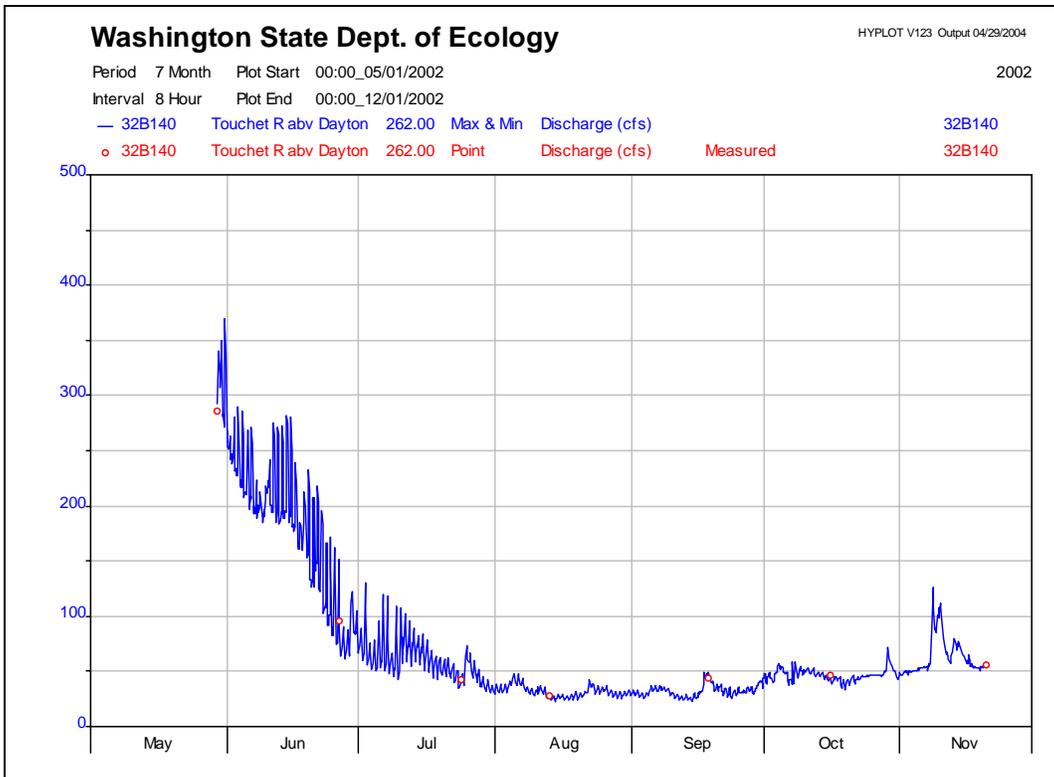


Figure 11: Discharge hydrograph for Site 3.

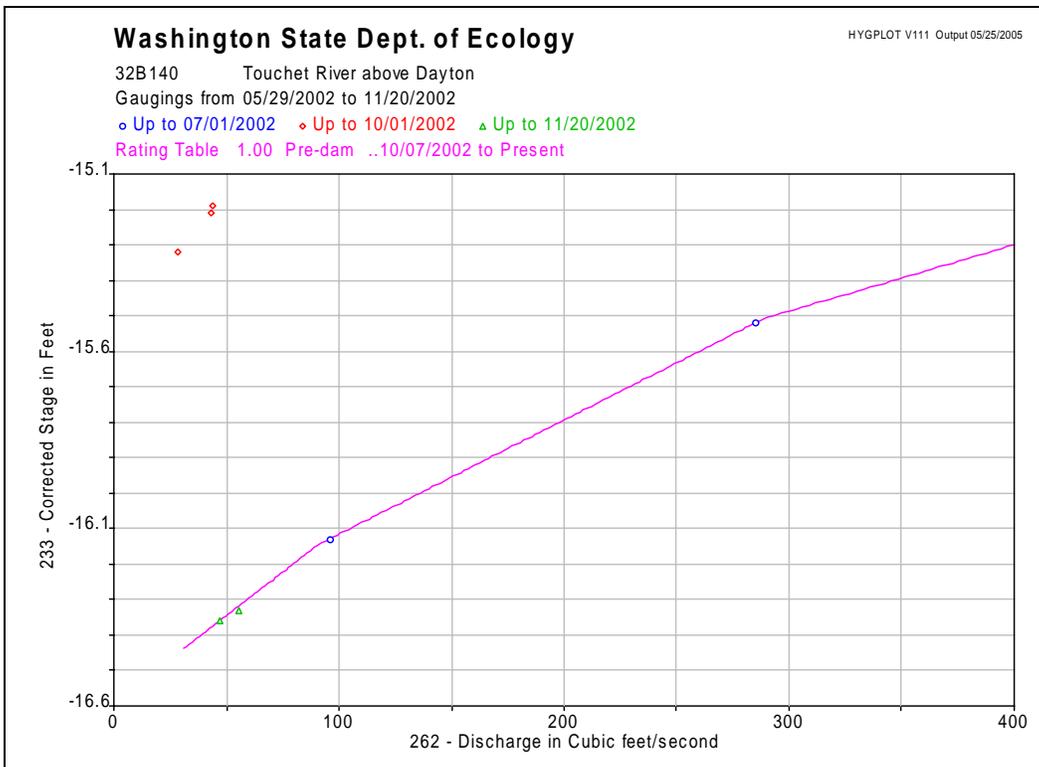


Figure 12: Discharge rating curve for Site 3.

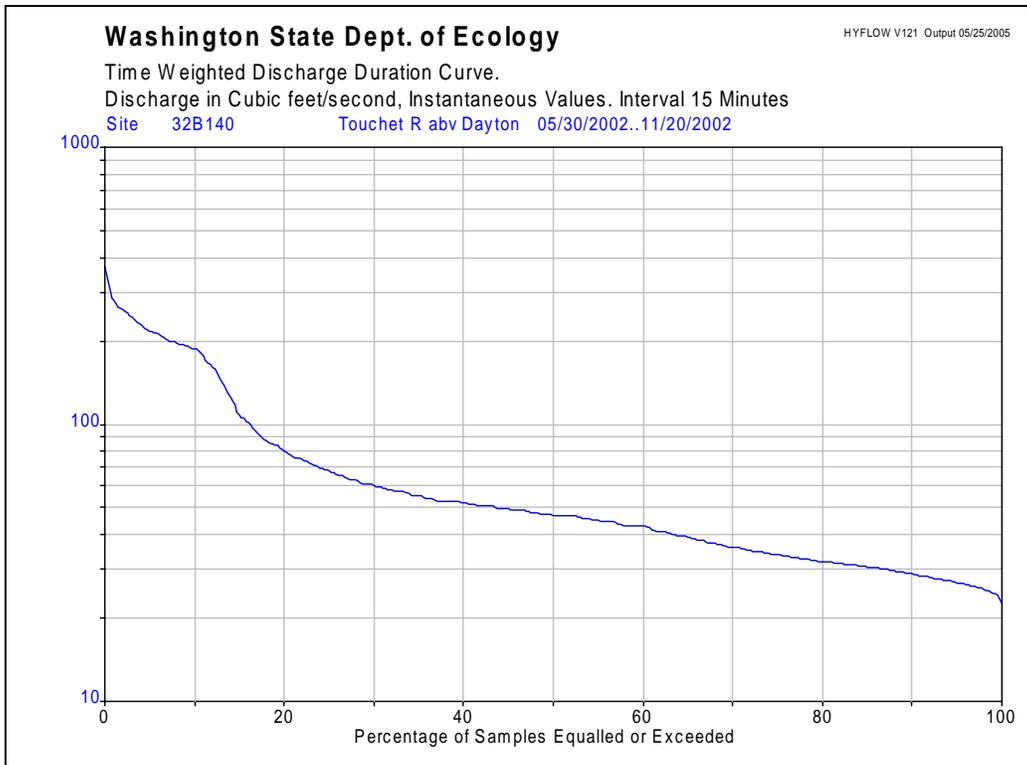


Figure 13: Discharge exceedence graph for Site 3.

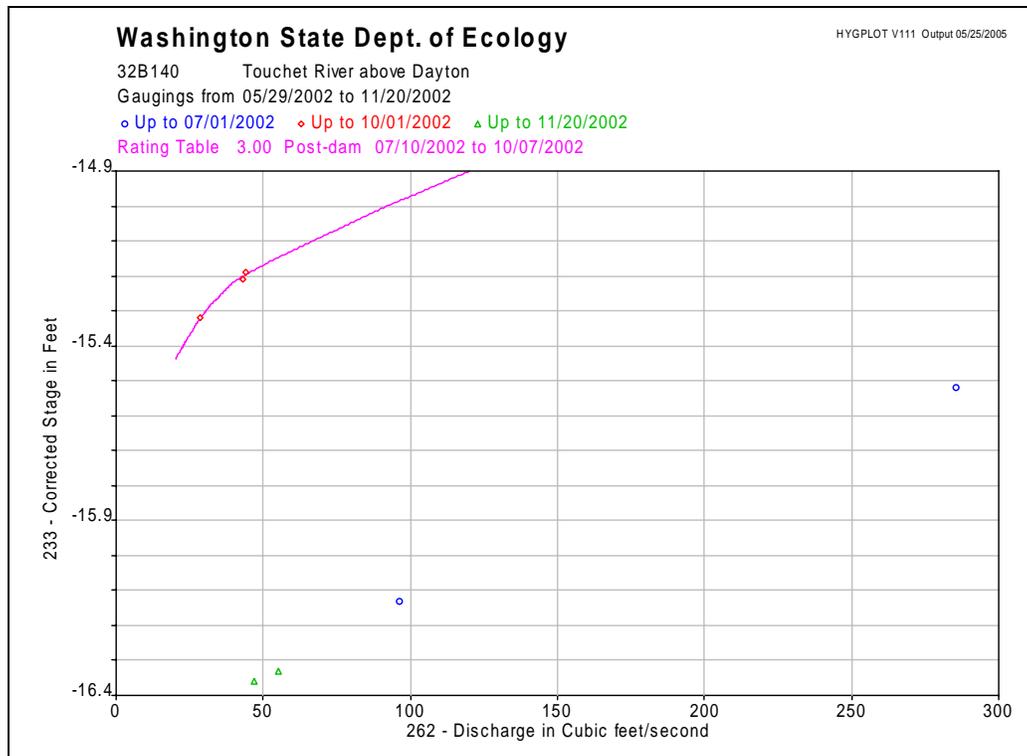


Figure 14: Discharge rating curve for Site 3 applied during presence of earthen dam.

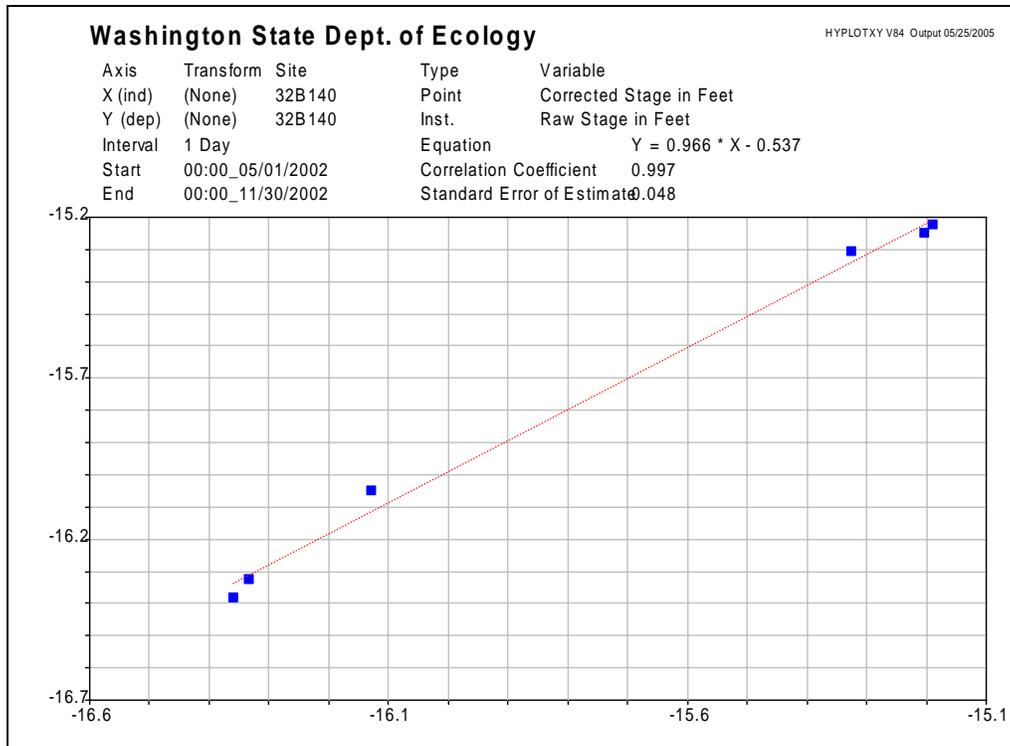


Figure 15: Linear regression of staff gage versus pressure transducer readings for Site 1.

Site 4: Yellowhawk Creek at Mouth

The average daily discharge for Site 4 ranged from 4.1 cfs in late-October to 61.2 cfs during spring snowmelt in May. Peak flow during the study period was 94.1 cfs on May 31 (Figure 16).

Daily discharge averages are presented in Appendix A, Table 4. The discharge rating curve for this site encompassed only 40% of the range of discharge encountered, with flow measurements ranging from 7.5 cfs to 49 cfs (Figure 17). However, discharge exceeded the rating curve less than 2% of the time over the duration of the study (Figure 18). Sometime between late-July and mid-August a shifting channel profile impacted the relationship between stage and discharge at this site. A new rating was developed to account for this change, which was most likely a somewhat gradual occurrence (Figure 19).

Within the range of measured flows, the fit of the rating curve was very good prior to the onset of channel movement, with all three discharge measurements within 5% of the flow predicted by the rating curve. After the onset of channel movement, however, the fit became poor due to the continuously changing channel geometry. None of the four measurements taken during this period were within 5% of the flow predicted by the rating curve, and only one was within 10%. Before corrective adjustments were made to the continuous data set, a linear regression of manual staff gage readings against pressure transducer readings had an r^2 of 0.976, indicating a moderate level of drift (Figure 20).

Due to channel aggradation and transducer drift at the site, the margin of error within the range of flows encountered is estimated to be $\pm 30\%$.

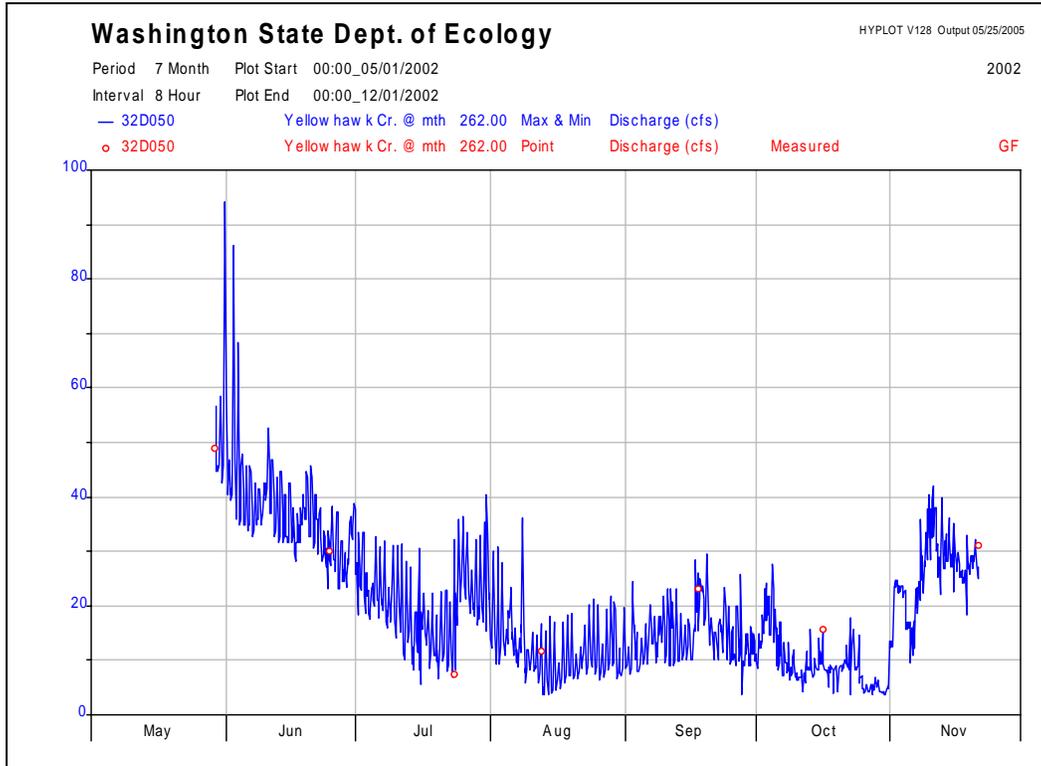


Figure 16: Discharge hydrograph for Site 4.

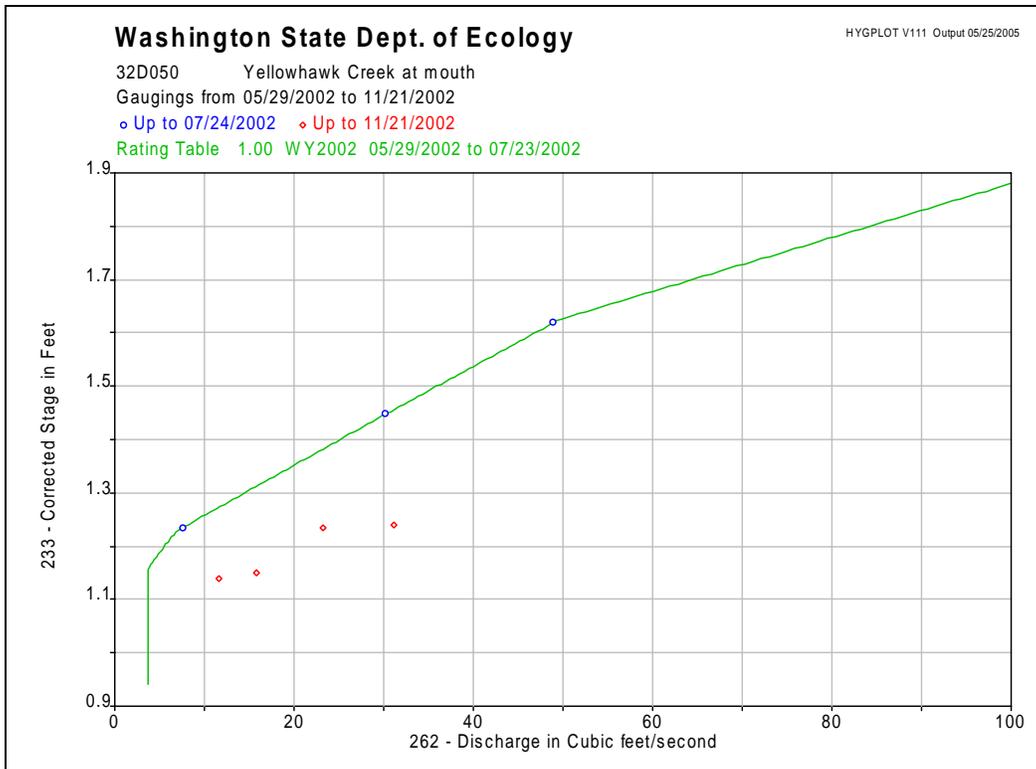


Figure 17: Discharge rating curve for Site 4.

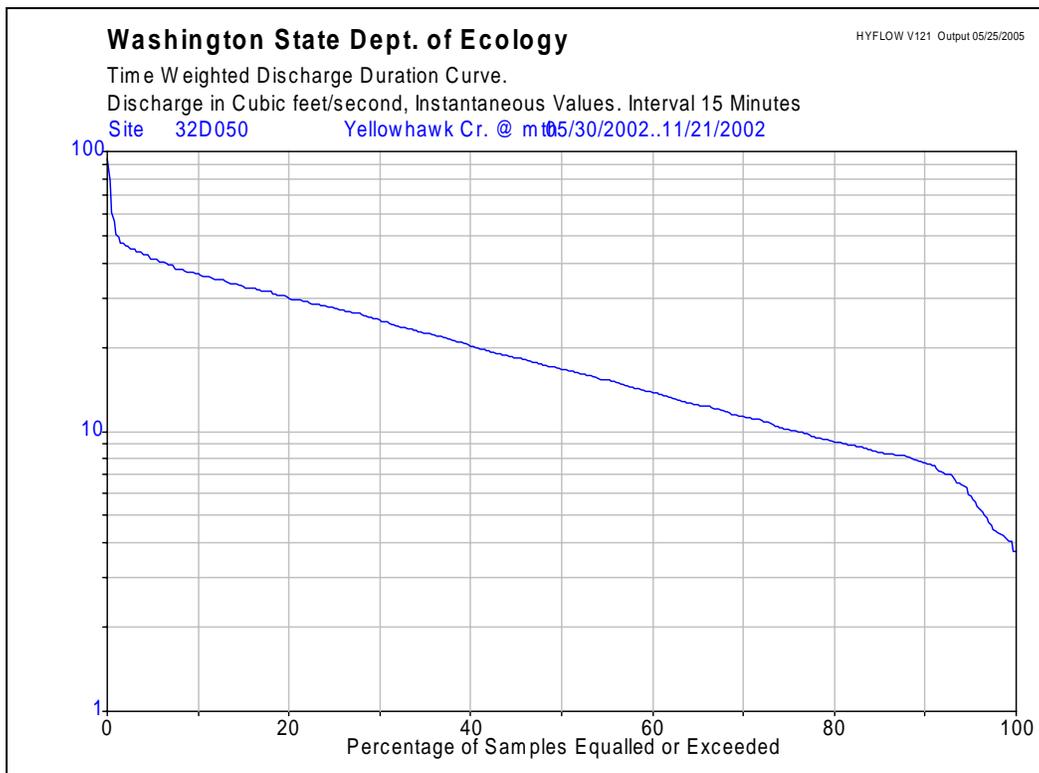


Figure 18: Discharge exceedance graph for Site 4.

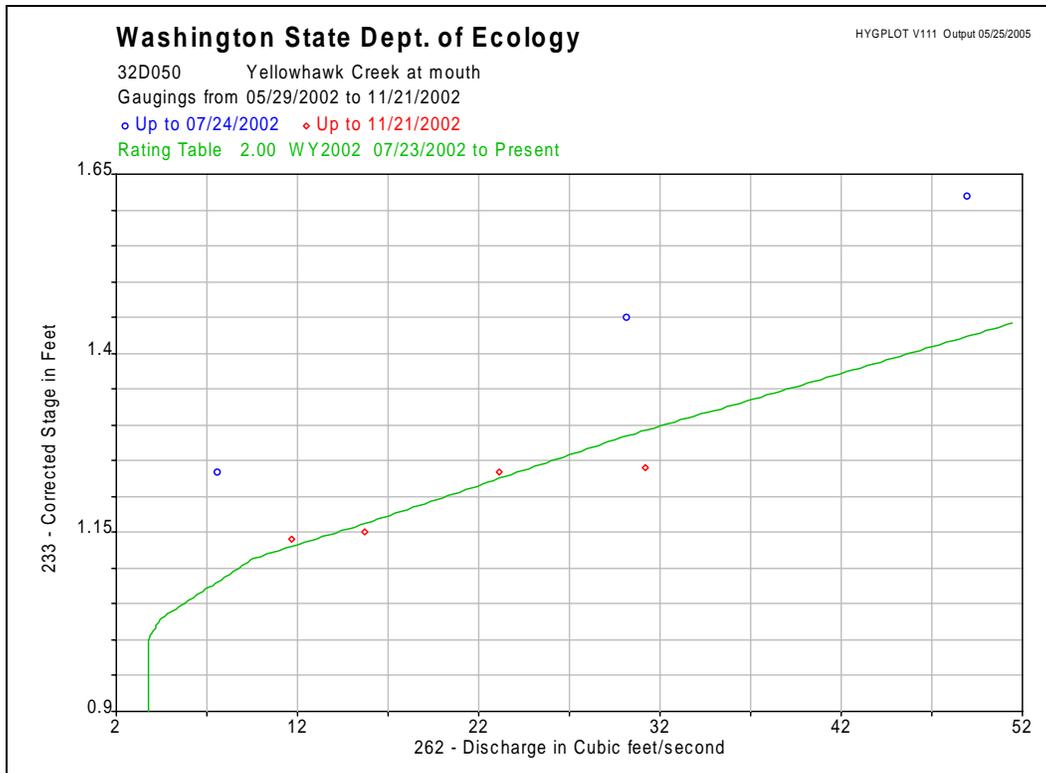


Figure 19: Discharge rating curve for Site 4 reflecting channel aggradation.

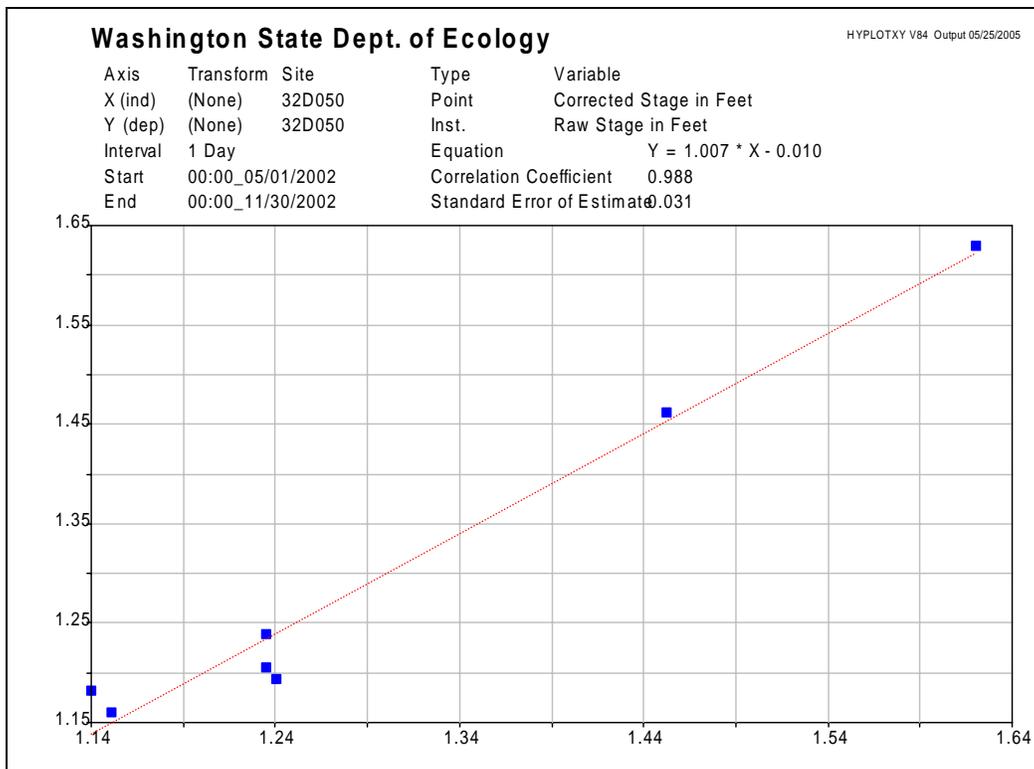


Figure 20: Linear regression of staff gage versus pressure transducer readings for Site 4.

Conclusions

The discharge analyses presented in this report were conducted in support of the temperature TMDL study of the Walla Walla watershed. Two types of variability in accuracy and quality are inherent in streamflow data: 1) variability between monitoring sites, and 2) variability within a single site at different times of year, and throughout the range of stage. Typically, the highest and lowest flows are the most difficult to monitor accurately. At the four sites monitored for this study, the range of interest was low flows. However, an effort was made to accurately predict flows throughout the range encountered. Below is a synopsis of the estimated accuracy for each of the four stations monitored during this study. The error margins presented are best professional judgement, based on conditions present at each site and the quantitative assessments of rating curve fit and instrument drift.

Discharge data for Site 1 are considered accurate to within $\pm 10\%$. The fit of the rating curve at this site was very good throughout the range of flows encountered during the study, and instrument drift did not occur. However, the lowest 15% of flows encountered at this site are extrapolated. Given the high predictability within the measured range of flows, the extrapolated low flows are likely accurate.

Discharge data for Site 2 are considered accurate to within $\pm 10\%$. The fit of the rating curve at this site was not as good as Site 1, but was still fairly good. Instrument drift at this site was nominal. The high source of error is due to a combination of factors. The high battery consumption at this site and the resulting data gaps contribute a large potential for error. In addition, the lowest 10% of flows encountered at this site are extrapolated. Some of the extrapolated data values occur during times when the data logger at this site was not operational. Data for periods where data for surrogate stations were used to supplement the data record at Site 2 are considered accurate to within $\pm 20\%$.

Discharge data for Site 3 are considered accurate to within $\pm 15\%$. The fit of the rating curve at this site was good. Logger drift and the presence of an earthen dam downstream of the site for part of the study period contributed to relatively high error. The dam was constructed during the onset of low flows, and the lowest 12% of flows are extrapolated, resulting in higher error potential in low flows than in high flows.

Discharge data for Site 4 are considered accurate to within $\pm 30\%$. The fit of the rating curve was good early in the study (late-May to late-July), but became very poor during the rest of the study. Instrument drift increased in severity during this time as well; likely a result of the changes in channel geometry. A moderate level of instrument drift, coupled with channel shifting resulted in high error potential at this site. Discharge data for May-June 2002 is considered to be accurate to within $\pm 10\%$.

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Appendix A: Average Daily Discharge Tables for 2002

Table 1: Average Daily Discharge for Site 1 – Touchet R. @ Luckenbill Rd

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	271	84.5	25.2B	23.0B	41.1	63.3
2	[]	254	78.7	24.8B	23.7B	44.5	72.6
3	[]	231	72.3	25.3B	23.0B	48.2	70.6
4	[]	214	68.5	26.7B	22.8B	50.9	69.6
5	[]	199	68.6	32.6	24.5B	55.3	66.5
6	[]	190	68.1	35.3	29.6	52.4	67.0
7	[]	180	65.0	35.9	31.1	49.1	59.4
8	[]	179	60.7	33.0	30.5	46.2	68.6
9	[]	178	63.0	29.0	29.9	44.5	88.4
10	[]	199	57.3	26.2B	28.5	44.3	93.4
11	[]	187	53.5	23.6B	25.1B	45.5	87.2
12	[]	166	50.7	25.1B	23.8B	47.7	75.5
13	[]	156	47.4	23.1B	22.2B	49.8	74.4
14	[]	152	44.9	19.8B	21.5B	51.7	80.8
15	[]	151	45.2	17.2B	21.2B	52.2	77.6
16	[]	144	40.8	19.1B	21.3B	49.9	72.3
17	[]	139	38.7	20.0B	27.7B	50.2	67.9
18	[]	149	35.6	20.4B	39.8	51.4	65.1
19	[]	170	35.1	21.8B	39.2	50.4	64.0
20	[]	141	37.6	24.6B	34.2	48.6	64.4
21	[]	127	36.3	24.4B	31.5	50.6	[]
22	[]	117	35.2	27.8B	31.7	54.0	[]
23	[]	108	32.6	34.8	30.3	54.5	[]
24	[]	102	30.2	32.7	29.3	56.1	[]
25	[]	94.7	29.2	29.9	29.0	58.1	[]
26	[]	87.2	35.0	28.8	30.6	59.1	[]
27	[]	79.8	35.0	28.6	31.6	59.6	[]
28	[]	78.2	33.4	25.7B	32.9	59.9	[]
29	341	88.9	32.2	22.9B	33.1	62.6	[]
30	352A	99.9	28.9	20.7B	36.9	68.5	[]
31	310		26.9B	21.4B		64.5	
Mean	334A	154	47.4B	26.0B	28.6B	52.3	72.4
Median	341A	151	40.8B	25.2B	29.5B	50.9	70.1
Max.Daily Mean	352A	271	84.5	35.9	39.8	68.5	93.4
Min.Daily Mean	310	78.2	26.9B	17.2B	21.2B	41.1	59.4
Inst.Max	376A	282	91.5	37.5	42.4	71.8	94.7
Inst.Min	276	76.1	24.5B	15.8B	19.7B	39.9	46.0
Missing Days	28	0	0	0	0	0	10

----- Notes -----
 All recorded data is continuous and reliable except where the following tags are used...
 A ... Above Rating, reliable extrapolation
 B ... Below rating, reliable extrapolation
 [] Data Not Recorded

Table 2: Average Daily Discharge for Site 2 – Touchet R. @ Bolles

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	261	94.8	35.8B	33.7B	45.5	54.6
2	[]	241	89.5	35.5	33.6B	47.4	56.0
3	[]	228	85.0	36.9B	32.0*	47.8	56.4L
4	[]	216	82.7	39.6	31.6*	53.5	57.1
5	[]	207	83.8	44.7	33.7*	52.0	58.3
6	[]	199	81.9	43.7	40.8*	49.3	59.1
7	[]	193	80.0	42.7	42.4*	46.9	58.5
8	[]	191	79.6	38.5	41.2*	44.8	71.9
9	[]	193	76.5	36.3	40.0*	43.8	79.9
10	[]	206	73.1	35.0B	37.7*	44.8	82.3
11	[]	189	70.3	37.3	32.6*	47.1	70.3
12	[]	181	68.9	36.1B	30.5*	47.0	64.3
13	[]	176	66.5	33.2B	27.9*	47.5*	67.6
14	[]	175	63.1	31.7B	26.7*	49.8*	69.2
15	[]	173	61.0	33.6B	25.9*	50.3*	66.1
16	[]	170	58.4	33.2B	25.8*	47.1*	62.1
17	[]	160	56.8*	32.0B	34.1*	46.9	59.5
18	[]	177	54.1*	31.9B	47.1*	47.4	59.1
19	[]	166	52.6*	34.6B	44.3	45.7	59.2
20	[]	149	54.3*	33.5B	40.1	46.3	60.5
21	[]	138	51.8*	35.7	41.1	48.7	[]
22	[]	128	49.4*	41.4	39.0	48.4	[]
23	[]	119	45.1*	41.9	37.4	49.1	[]
24	[]	112*	43.2*	38.5	36.8	49.9	[]
25	[]	106*	46.7	37.4	37.4	50.8	[]
26	[]	102*	49.0	37.5	37.9	51.5	[]
27	[]	100*	47.2	35.6	38.6	51.5	[]
28	[]	97.4	45.5	33.6B	39.3	52.2	[]
29	[]	114	42.5	32.9B	40.0	58.0	[]
30	[]	106	39.6	33.3B	44.6	57.8	[]
31	283		37.0	33.8B		54.2	
Mean	283	166*	62.3*	36.4B	36.5*	49.1*	63.6L
Median	283	174*	58.4*	35.7B	37.6*	48.4*	60.0L
Max.Daily Mean	283	261	94.8	44.7	47.1*	58.0	82.3
Min.Daily Mean	283	97.4	37.0	31.7B	25.8*	43.8	54.6
Inst.Max	303	271	98.0	47.5	48.8*	62.8	86.0
Inst.Min	260	94.5	34.3	29.8B	23.9*	41.3	52.6
Missing Days	30	0	0	0	0	0	10

----- Notes -----
 All recorded data is continuous and reliable except where the following tags are used...
 * ... Data estimated based on other stations
 B ... Below rating, reliable extrapolation
 L ... Linear interpolation across gap in data
 [] Data Not Recorded

Table 3: Average Daily Discharge for Site 3 – Touchet R. abv Dayton

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	256	73.0	33.3	30.3	43.2	47.3
2	[]	249	74.7	33.7	29.6B	45.1	49.3
3	[]	238A	61.6	34.8	28.0B	43.9	49.9
4	[]	229	61.2	39.2	29.0B	53.4	51.0
5	[]	221	66.8	42.5	34.0	50.9	52.1
6	[]	216	69.9	41.4	34.0	44.7	53.0
7	[]	202	63.9	37.0	34.9	46.1	54.7
8	[]	198	55.4	32.9	33.7	53.5	90.7
9	[]	200	59.6	31.1	31.4	50.4	95.7
10	[]	220	61.6J	31.5	28.5B	50.6	98.0
11	[]	213	77.7	33.0	27.1B	50.5	69.6
12	[]	208	72.3	29.9B	26.1B	48.7	62.3
13	[]	209	69.9	26.7B	26.5B	47.3	75.5
14	[]	212	69.4	25.8B	25.0B	46.3	73.4
15	[]	207	66.6	27.3B	27.3B	44.6	64.3
16	[]	187	62.3	26.3B	30.1B	42.2	58.1
17	[]	167	57.0	26.0B	41.3	43.1	55.8
18	[]	182	53.4	26.8B	44.6	40.3	53.0
19	[]	168	53.4	28.6B	37.5	37.9	53.5
20	[]	148	52.3	27.9B	35.1	40.8	[]
21	[]	156	52.6	30.7	33.9	43.3	[]
22	[]	134	48.1	36.5	30.8B	43.1	[]
23	[]	117	42.9	34.4	30.6B	44.3	[]
24	[]	108	40.2	33.3	31.0	45.8	[]
25	[]	99.7	59.5	33.9	32.0	46.8	[]
26	[]	84.8	55.9	32.6	31.6	46.9	[]
27	[]	72.4	49.5	30.5B	32.9	46.4	[]
28	[]	70.9	44.2	28.9B	32.9	48.3	[]
29	[]	102	37.7	29.2B	36.2	61.9	[]
30	319A	85.0	35.9	29.4	39.7	53.5	[]
31	297A		32.7	30.4		46.0	
Mean	308A	172A	57.5J	31.8B	32.2B	46.8	63.5
Median	308A	193A	59.5J	31.1B	31.5B	46.1	55.8
Max.Daily Mean	319A	256A	77.7	42.5	44.6	61.9	98.0
Min.Daily Mean	297	70.9	32.7	25.8B	25.0B	37.9	47.3
Inst.Max	370A	290A	131	47.7	49.7	71.3	127
Inst.Min	258	60.6	28.9	22.9B	22.6B	32.6	46.9
Missing Days	29	0	0	0	0	0	11

----- Notes -----
 All recorded data is continuous and reliable except where the following tags are used...
 A ... Above Rating, reliable extrapolation
 B ... Below rating, reliable extrapolation
 J ... Estimated Data
 [] Data Not Recorded

Table 4: Average Daily Discharge for Site 4 – Yellowhawk Cr. @ mouth

Day	May	Jun	Jul	Aug	Sep	Oct	Nov
1	[]	45.3A	26.2	19.0	9.37B	11.6B	13.8
2	[]	54.6A	27.3	14.4B	14.2B	15.8	23.7
3	[]	47.3A	22.2	17.2B	11.9B	20.2	22.7
4	[]	41.7	20.8	13.6	11.1B	21.2	19.7
5	[]	39.4	25.0	18.5	12.0B	15.9B	15.9B
6	[]	39.5	22.9	13.0B	15.8B	12.9B	17.9
7	[]	36.9	22.8	11.8B	15.1B	11.1B	23.9
8	[]	38.0	19.6	22.7B	14.5	9.73B	27.6
9	[]	38.6	22.5	9.27B	17.1	9.31B	33.8
10	[]	45.3A	21.3	11.0B	16.0B	7.22B	36.5
11	[]	42.2	20.2	9.47B	15.3B	6.89B	32.4
12	[]	38.3	17.4	8.67B	14.9B	7.88B	29.4
13	[]	38.6	16.8	8.05U	13.4	9.88B	29.8
14	[]	35.9	13.1	8.29U	13.2	8.59B	30.0
15	[]	36.6	15.5B	7.79B	12.9	11.0B	29.3
16	[]	32.8	18.2	6.63B	12.9	10.7B	27.9
17	[]	32.4	15.7	9.53B	19.8	8.01B	25.5
18	[]	36.7	13.7	10.7B	22.7	8.00B	27.3
19	[]	39.6	11.0	10.4B	22.3	8.24B	28.0
20	[]	37.8	13.8B	8.21B	15.6	8.24B	29.3
21	[]	35.5	14.1	8.82B	13.2	9.66B	[]
22	[]	33.2	12.9	12.1B	13.9	8.91U	[]
23	[]	30.8	15.7	12.1B	16.9	11.3B	[]
24	[]	29.9	24.0	13.1B	15.4	8.62B	[]
25	[]	31.9	26.6	11.3B	12.1B	5.50B	[]
26	[]	30.5	27.4	9.07B	13.5B	4.57B	[]
27	[]	26.6	21.8	11.3B	12.0U	4.81U	[]
28	[]	26.2	22.7	13.3B	11.3B	5.59B	[]
29	[]	31.6	22.7	12.6B	11.2B	4.76B	[]
30	50.7A	34.4	22.6	8.38B	12.2	4.13B	[]
31	61.2A		25.6	12.2B		7.06B	
Mean	56.0A	36.9A	20.1B	11.7U	14.4U	9.59U	26.2B
Median	56.0A	36.8A	21.3B	11.3U	13.7U	8.62U	27.8B
Max.Daily Mean	61.2A	54.6A	27.4	22.7	22.7	21.2	36.5
Min.Daily Mean	50.7	26.2	11.0B	6.63U	9.37U	4.13U	13.8B
Inst.Max	94.1A	86.2A	40.4	36.1	29.5	27.7	42.0
Inst.Min	42.5	23.0	5.66B	3.75U	3.75U	3.75U	9.58B
Missing Days	29	0	0	0	0	0	10

----- Notes -----
 All recorded data is continuous and reliable except where the following tags are used...
 A ... Above Rating, reliable extrapolation
 B ... Below rating, reliable extrapolation
 U ... Unknown flow, less than value shown
 [] Data Not Recorded